

Time Varying Electric Field Inputs



- Binary (B3D) or text (csv) file formats
- Include times points and geo-spatial (longitude, latitude) grid with Eastward and Northward E-field at each point

Time Varying Electric Field Inputs



- Coarse Grid File (required)
 - specifies time points and resolution (in degrees latitude and longitude) of geo-spatial grid
 - contains Eastward and Northward E-field magnitude for each grid point and time
- Fine Grid Files (optional)
 - detailed data at a higher spatial resolution than the Coarse Grid
 - may be used for regions with high E-field gradients (e.g. coastal effects)

Example: B3D File



- Open case **TN150.pwb** and the *GIC Analysis Form*
- Choose **Calculation Mode** “Time Varying Electric Field Inputs”
- Load *Coarse Grid File* **TN_20150622.b3d** (from *Browse...* button)

Example: B3D File



Change Time Point to view its grid points

Summary

Input Summary

| | | | | | |
|-------------------------|--|--------------------------|------------------------------------|---|-------------------------------------|
| Starting Time (Seconds) | <input type="text" value="0.00"/> | Starting Latitude | <input type="text" value="34.00"/> | Starting Longitude | <input type="text" value="-90.00"/> |
| Ending Time (Seconds) | <input type="text" value="172790.00"/> | Ending Latitude | <input type="text" value="37.00"/> | Ending Longitude | <input type="text" value="-82.00"/> |
| Number of Time Points | <input type="text" value="17280"/> | Latitude Increment | <input type="text" value="0.500"/> | Longitude Increment | <input type="text" value="0.500"/> |
| Non-Uniform Time Point | <input type="text" value="0.0000"/> | Preview Offset (Seconds) | <input type="text" value="0.00"/> | <input type="button" value="Preview Time"/> | |

Time Point
Grid Data

Time Point Grid Preview (First Entry is the Eastward Value, the Second the Northward)

| Lat | Lon: -90.000 | Lon: -89.500 | Lon: -89.000 | Lon: -88.500 | Lon: -88.000 | Lon: -87.500 | Lon: -87.000 |
|--------|--------------|--------------|--------------|---------------|--------------|---------------|---------------|
| 37.000 | 0.007,-0.004 | 0.003,-0.003 | 0.003,-0.001 | 0.002, 0.000 | 0.001, 0.000 | 0.002, 0.001 | 0.003, 0.000 |
| 36.500 | 0.004,-0.003 | 0.001,-0.002 | 0.002,-0.001 | 0.002, 0.000 | 0.002, 0.001 | 0.001, 0.001 | 0.004,-0.000 |
| 36.000 | 0.002,-0.001 | 0.000,-0.001 | 0.001,-0.001 | 0.001, 0.000 | 0.002, 0.000 | 0.002, 0.000 | 0.001, 0.000 |
| 35.500 | 0.002,-0.001 | 0.002,-0.000 | 0.003, 0.000 | -0.000, 0.000 | 0.000, 0.000 | 0.001, 0.002 | 0.001, 0.001 |
| 35.000 | 0.002,-0.001 | 0.002,-0.001 | 0.002,-0.000 | 0.002, 0.000 | 0.001, 0.000 | -0.001, 0.001 | -0.000, 0.001 |
| 34.500 | 0.002,-0.001 | 0.002,-0.001 | 0.002,-0.001 | 0.002,-0.000 | 0.002, 0.000 | 0.007, 0.002 | -0.001, 0.001 |
| 34.000 | 0.002,-0.000 | 0.002,-0.000 | 0.002,-0.000 | 0.002,-0.000 | 0.002,-0.001 | 0.002, 0.000 | 0.005, 0.001 |

GIC Calculation and Power Flow



- Set the “Current Time” to match desired time point
- Optionally check “Include GIC in Power Flow and Transient Stability”
- Click “Calculate GIC Values” and/or solve the power flow

GIC Analysis Form

Calculation Mode
 Single Snapshot
 Time Varying Series Voltage Inputs
 Time Varying Electric Field Inputs

Buttons: Calculate GIC Values, Clear GIC Values, Include GIC in Power Flow and Transient Stability, Validate Input Data for C

Current Time: 68000.00 Calculate GIC on Time Change Use EMP as Input Load Time-Varying Input and Ca

Select Step

- Field/Voltage Input
 - Options
 - DC Current Calculation
 - AC Power Flow Model
 - Tables and Results
 - Areas
 - Buses
 - Generators
 - G-Matrix
 - Lines
 - Line Shunts
 - Switched Shunts
 - Substations
 - System Summary

Tables and Results

| Area | Bus Num High | Bus Name High | Bus Num Med | Bus Name Med | Bus Num Ter | Bus Name Ter | Circuit | Transform Per Phase Effective (Amps) | Transformer Per Unit Effective GIC | GIC Loss |
|------|--------------|----------------------------|-------------|----------------------------|-------------|--------------|---------|--------------------------------------|------------------------------------|----------|
| 1 | 103 | ELIZABETHTON_37643_500.0 | 45 | ELIZABETHTON_37643_230.0 | 0 | 1 | 1.027 | 0.006 | | |
| 2 | 148 | Pickwick Landing Dam_500.0 | 147 | Pickwick Landing Dam_230.0 | 0 | 1 | 0.917 | 0.006 | | |
| 3 | 108 | CLARKSVILLE_37040_500.0 | 14 | CLARKSVILLE_37040_230.0 | 0 | 1 | 0.808 | 0.005 | | |
| 4 | 104 | CORDOVA_38016_500.0 | 71 | CORDOVA_38016_230.0 | 0 | 1 | 0.782 | 0.005 | | |
| 5 | 99 | MEMPHIS_38111_500.0 | 79 | MEMPHIS_38111_230.0 | 0 | 1 | 0.779 | 0.005 | | |
| 6 | 99 | MEMPHIS_38111_500.0 | 79 | MEMPHIS_38111_230.0 | 0 | 2 | 0.779 | 0.005 | | |

Calculate Entire Time Series in Transient Stability



- Return to **Field/Voltage Input** page
- Optionally adjust “Start Time”, “End Time”, or “Sampling Rate”
- Click “Setup Time Varying Series” button
- Equivalent Transmission Line inputs are created for the **Calculation Mode** “Time Varying Electric Field Inputs”

Setup Time Varying Series Voltage Inputs

| | | |
|-------------------------|-----------|--------|
| Start Time (Seconds) | 0.00 | ▲ ▼ |
| End Time (Seconds) | 172790.00 | ▲ ▼ |
| Sampling Rate (Seconds) | 10.00 | ▲ ▼ |

Setup Time Varying Series

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Time Varying Series Voltage Inputs



- Change **Calculation Mode** to “Time Varying Series Voltage Inputs”
- Time Points created at sampling interval between Start Time and End Time

Field/Voltage Input

AC Line Input Voltages

| | Branch ID | From Number | To Number | Circuit | From Latitude | To Latitude | From Longitude | To Longitude | Distance Between Substations (km) | Timepoi | Timepoi | Timepoi | Timepoi | Timepoi | Timepoi | Timepoi | Timepoi |
|---|----------------------|-------------|-----------|---------|---------------|-------------|----------------|--------------|-----------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| 1 | Time in Seconds | | | | | | | | | 0.000 | 10.000 | 20.000 | 30.000 | 40.000 | 50.000 | 60.000 | 70.000 |
| 2 | Branch '144' '1' '1' | 144 | 1 | 1 | 36.0282 | 36.0282 | -87.9858 | -87.9858 | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 3 | Branch '2' '14' '1' | 2 | 14 | 1 | 36.4362 | 36.4751 | -86.8408 | -87.2991 | 41.31 | 0.012 | -0.001 | 0.006 | -0.004 | 0.003 | -0.009 | -0.015 | -0.003 |
| 4 | Branch '2' '21' '1' | 2 | 21 | 1 | 36.4362 | 36.2387 | -86.8408 | -86.7329 | 23.96 | -0.061 | -0.049 | -0.038 | -0.030 | -0.023 | -0.019 | -0.021 | -0.029 |
| 5 | Branch '19' '3' '1' | 19 | 3 | 1 | 35.9840 | 36.2233 | -86.5424 | -86.1935 | 41.14 | 0.045 | 0.054 | 0.036 | 0.046 | 0.030 | 0.045 | 0.055 | 0.044 |
| 6 | Branch '141' '3' '1' | 141 | 3 | 1 | 36.3156 | 36.2233 | -86.4004 | -86.1935 | 21.22 | -0.013 | -0.006 | -0.006 | -0.002 | -0.002 | 0.002 | 0.003 | -0.004 |
| 7 | Branch '4' '18' '1' | 4 | 18 | 1 | 36.0522 | 36.1306 | -86.6325 | -86.6131 | 8.87 | 0.011 | 0.011 | 0.008 | 0.008 | 0.005 | 0.007 | 0.009 | 0.009 |

GIC in Transient Stability




- Open **Transient Stability** dialog and go to **Options → Power System Model → Common** page
- Check “Just Calculate GIC with No Network Solution” (allows fast computation of time-varying GIC quantities without transient stability numeric integration)

—Geomagnetic Induced Current Options—

Include GIC Effects (Option Set on GIC Form)

Just Calculate GIC with No Network Solution

GIC XF Time Constant (Sec) 

GIC in Transient Stability



- Go to **Simulation** → **Control** page
- Set the Start Time, End Time, and Time Step to correspond to the GIC input data (or any desired subset)

Simulation Add... C

Control Definitions Violations

Simulation Time Values

Start Time (seconds) 0.000

End Time (seconds) 172790.000

Time Step (seconds) 10.000000

Specify Time Step in

Seconds

Cycles

Results Storage



- Go to **Results Storage** page and subpages
- *Save XF GIC I Effective* for all **Transformers** and *Save GIC Total Mvar Losses* for **Case Information**

Result Storage

Where to Save/Store Results Save Results Every n Timesteps:

Store Results to RAM Save Results to Hard Drive Do Not Combine RAM Results with Hard Drive Results

Save the Results stored to RAM in the PWB file Save the Min/Max Results stored to RAM in the PWB file

Store to RAM Options Save to Hard Drive Options

Note: All fields that are specified in a plot series of defined plot will also be stored to RAM.

Store Results for Open Devices Set All to NO for All Types

Switched Shunt Branch Transformer DC Transmission Line VSC DC Line Multi-Terminal DC Record Multi-Terminal DC Converter A

Set All NO Records Set Columns

| From Selection: | From Number | From Name | To Number | To Name | Circuit | Save XF Tap | Save XF Phase | Save XF GIC I Effective | Save XF GIC Mvar | Save XF G Ne |
|-----------------|-------------|-----------------|-----------|-----------------|---------|-------------|---------------|-------------------------|------------------|--------------|
| 1 | 144 | Johnsonville_50 | 1 | Johnsonville_g4 | 1 | NO | NO | YES | NO | NC |
| 2 | 8 | MURFREESBOR | 102 | MURFREESBOR | 1 | NO | NO | YES | NO | NC |
| 3 | 11 | CLARKSVILLE_3 | 98 | CLARKSVILLE_3 | 1 | NO | NO | YES | NO | NC |
| 4 | 14 | CLARKSVILLE_3 | 108 | CLARKSVILLE_3 | 1 | NO | NO | YES | NO | NC |
| 5 | 22 | NASHVILLE_372 | 101 | NASHVILLE_372 | 1 | NO | NO | YES | NO | NC |
| 6 | 22 | NASHVILLE_372 | 101 | NASHVILLE_372 | 2 | NO | NO | YES | NO | NC |
| 7 | 23 | MURFREESBOR | 96 | MURFREESBOR | 1 | NO | NO | YES | NO | NC |

Plot Results



- Click “Run Transient Stability”
- Go to Plots page and create plots
 - *Device Type* “Transformer” and *Field* “XF GIC I Effective”
 - *Device Type* “Case Information” and *Field* “GIC Total Mvar Losses”
- Details on plotting tool are covered in the Transient Stability Training

